Strategy Research Project

The Signal Corps' Strategic Vision in a Resource Constrained Environment

by

Colonel Douglas J. Orsi
United States Army

United States Army War College
Class of 2012

The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
13-02-2012	Strategy Research Project	

4. TITLE AND SUBTITLE
The Signal Corps' Strategic Vision in a Resource Constrained Environment

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Colonel Douglas J. Orsi

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Dr. Michael Neiberg
Department of National Security &
Strategy

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army War College
122 Forbes Avenue
Carlisle, PA 17013

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution: A

13. SUPPLEMENTARY NOTES

14. ABSTRACT
World War I ushered in the use of many new technologies on the battlefield, including chemical weapons, tanks, and flamethrowers, as well as communication technologies such as portable radios and radiotelephony. The war concluded as some of these new radio technologies were maturing for use in battle. Reduced defense spending in the interwar period limited new equipment development in the U.S. Army Signal Corps, but on the commercial side, the field of radio and telephone communications grew exponentially. The reduction in military spending and limited vision of Signal Corps strategic leaders resulted in the Army's divisions and mechanized forces having inadequate communications equipment at the start of World War II. This paper argues that Signal Corps leadership lacked a clear vision of the future and failed to embrace FM radio technology for equipping the future force. The Signal Corps reliance on how it fought the last war hindered its vision for fighting the next one. Today's Signal Corps can glean many insights from this period, which may prove useful in this era of reduced defense spending.

15. SUBJECT TERMS
AM and FM Radio, Radiotelegraphy, Radiotelegraph, Wire, Communications, 1930s, Motorization, Mechanization

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFED	UNCLASSIFED	UNCLASSIFED	UNLIMITED	40	

USAWC STRATEGY RESEARCH PROJECT

THE SIGNAL CORPS' STRATEGIC VISION IN A RESOURCE CONSTRAINED ENVIRONMENT

by

Colonel Douglas J. Orsi
United States Army

Dr. Michael Neiberg
Project Adviser

This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Colonel Douglas J. Orsi

TITLE: The Signal Corps' Strategic Vision in a Resource Constrained Environment

FORMAT: Strategy Research Project

DATE: 13 February 2012 WORD COUNT: 8,524 PAGES: 40

KEY TERMS: AM and FM Radio, Radiotelegraphy, Radiotelegraph, Wire, Communications, 1930s, Motorization, Mechanization

CLASSIFICATION: Unclassified

World War I ushered in the use of many new technologies on the battlefield, including chemical weapons, tanks, and flamethrowers, as well as communication technologies such as portable radios and radiotelephony. The war concluded as some of these new radio technologies were maturing for use in battle. Reduced defense spending in the interwar period limited new equipment development in the U.S. Army Signal Corps, but on the commercial side, the field of radio and telephone communications grew exponentially. The reduction in military spending and limited vision of Signal Corps strategic leaders resulted in the Army's divisions and mechanized forces having inadequate communications equipment at the start of World War II. This paper argues that Signal Corps leadership lacked a clear vision of the future and failed to embrace FM radio technology for equipping the future force. The Signal Corps reliance on how it fought the last war hindered its vision for fighting the next one. Today's Signal Corps can glean many insights from this period, which may prove useful in this era of reduced defense spending.

THE SIGNAL CORPS' STRATEGIC VISION IN A RESOURCE CONSTRAINED ENVIRONMENT

The United States military operates in a 21st century global environment that is both complicated and rapidly changing. The United States (U.S.) Army War College describes this environment as, "volatile, uncertain, complex, and ambiguous [VUCA]."[1] Our federal government's budget crisis and declining defense spending make this environment even more difficult.[2] The VUCA environment is not new, and strategic leaders have always attempted to posture their organizations in order to win the next war. To accomplish this goal, strategic leaders must master competencies that allow them to achieve tangible results in a VUCA environment. One of the most important and critical Strategic Leader competency, and one that mutually supports all others is "Envisioning the Future".[3] By viewing the exercise of this competency in historical examples from strategic leaders and thinkers inside and outside the U.S. Army Signal Corps, we can learn how to develop it in ourselves for success in future endeavors.

The most critical function of strategic leaders is to envision the future to guide or move their organizations forward. The U.S. Army's *Field Manual (FM) 6-22, Army Leadership* states, "the ability to provide clear vision is vital to the strategic leader."[4] John Kotter, author of *Leading Change*, calls this process "Developing a Vision and Strategy."[5] This paper reviews the strategic vision of the Signal Corps during the 1930s prior to World War II. The task for the Signal Corps strategic leaders was to envision how the Army would equip its combat divisions with communications for the next war.[6] Each senior strategic leader needs to answer the question of how to prepare organizations for an unpredictable future.

In order to be successful in a VUCA environment, strategic leaders must envision their organization at a point in the future and provide their subordinates what Kotter called, “an imaginable picture of the future.”[7] For military leaders, envisioning the future enables the correct force structure and equipment for winning the next conflict. Yet, as Brigadier General Bradford G. Chynoweth, who served in both World Wars lamented, “In that interim period between wars, many of the top men in the Army had made their success in war, but were not looking forward to any future war.”[8] For the pre-World War II Signal Corps, envisioning the future meant embracing the idea that mechanization and motorization were the future of warfare and enabling them to communicate.[9] Leaders were also determining if the Signal Corps should embrace new technologies to solve the problems associated with radio communications in the combat arms.[10] While the Signal Corps was building its vision, the nation was still in the grip of a global depression.

Contemporary Signal Corps strategic leaders and thinkers need to regard these same issues as we begin to move through a similar period of reduced defense spending and decreased force structure. A strategic leader or thinker has to use their wisdom, judgment, and accumulated acumen to describe the future in their vision.

In the 1930s, new ideas came from stakeholders both within the Signal Corps and military as well as outside sources like industry and they directly influenced the future vision of communications in the Army. A critical component of envisioning the future is building a vision. In most cases, creating a vision is an integration of ideas, with strategic leaders “guiding the process.”[11] Although it is critical to form a team from within to help build a vision, leaders must also look outside their organizations for input. *Army*

Leadership states, “Strategic leaders are open to ideas from many sources, not just their own organizations.”[12]

During the 1930s, strategic leaders and thinkers within the Signal Corps and industry communicated competing visions of radio within the Army. The correct role of radio in the Army was the prize that they all sought. Simultaneously, tension existed between the Signal Corps and the combat arms branches of the Army, who demanded more radios to support their vision of mechanized and motorized forces. Wire communications did not support these forces, which required reliable, mobile communications to support long-range operations.

To understand these strategic leaders, thinkers, and their visions, one must understand the period between the conclusion of World War I and the late 1930s. This period influenced and shaped the strategic leaders and thinkers who were envisioning the future military use of radio and its use in the next war. To understand radio technology and development in this period, one must first understand its past.

History

World War I ushered in the use of many new technologies on the battlefield, including chemical weapons, tanks, and flamethrowers. Also introduced were a number of communication technologies, including the use of portable radios and radiotelephony on the ground and in aircraft.[13] When the guns fell silent on November 11, 1918, some of these communication technologies were on the brink of maturation on and above the battlefield with the American Expeditionary Forces (AEF). Examples included a 3-man transportable (three sections of less than 30 lbs. each) two-way radio loop set with small antennas that had a six-mile range. They also included the development of a radiotelephone set for aircraft, which allowed pilots to communicate by voice rather than

telegraph key.[14] Yet because the war ended before full maturation and mass production, "radio carried little of the war's communications load."[15] Wire communications, such as the field telephone, were the main means of communication, from regiment through the corps, in France during the war.[16] Although combat arms units used carrier pigeon, signal panels and runners, the primary means of communication was over wire, via the field phone or field telegraph.[17] This institutional knowledge and reliance on wire communications had a lasting impact on the minds of key senior strategic leaders within the Signal Corps and influenced their visions for the future of the branch in the next war. Future Chiefs of Signal Major Generals Carr, Allison and Mauborgne maintained a reliance on wire when the future was moving toward radio communications in the Army and the combat arms.

The Signal Corps made great gains in radio technology during the war due in part to the increase in funding and the influence of French communication equipment, which was the only gear initially available to the AEF.[18] Yet the greatest influence on the Signal Corps was the massive influx of telephone and radio engineers and scientists, who came in via the Officer's Reserve Program. John J. Carty was the first officer commissioned through the Signal Reserve Corps in 1916. He had served as Chief Engineer at American Telephone and Telegraph (AT&T) and rose to the rank of Colonel while serving in the AEF in France during the war. Later, he attained the rank of Brigadier General, Signal Corps Reserve and retired from AT&T as Vice President.[19] There was also Robert A. Millikan, a physics professor from the University of Chicago, who headed the Signal Corps' Science and Research Division.[20] Another example was Edwin H. Armstrong, an associate professor in Electrical Engineering at Columbia

University, who as a Signal Corps captain continued to experiment, design, and improve radio communications while in France with the AEF.[21] Many of these men maintained their status as Signal Reserve officers during the interwar period and had a significant influence on the vision of how to support the Army with communications during wartime.

The Armistice of November 11, 1918 and subsequent Versailles Peace Treaty ended the war and drastically reduced the size and scope of the Signal Corps, which inhibited its ability to develop improved military radios. The National Defense Act of 1920 made further changes in reducing the structure and organization of the Signal Corps. Budgetary constraints continued to reduce the Signal Corps until 1926, when it had less than 2,200 enlisted men.[22] The reduced budgets and personnel limited the Signal Corps' ability to invest and experiment in radio technology. The Great Depression further reduced military budgets through the 1930s.

Despite limited budgets over the next two decades, the Signal Corps' Laboratories continued to improve and invent radio and wire communications equipment with its limited resources. Improvements occurred in portable ground and aircraft radios, field telephones, wire, telegraph and switchboards.[23] The Army codified its technical means to command and control in the 1923 edition of *Field Service Regulations*, which was the "basis of instruction of the combined arms for war service."[24] The section, "Transmission of Orders, Information, and Reports" stated, "The telegraph and telephone constitute the basic means of signal communication."[25] It also stated that radio was "applicable to employment in spanning distances between widely separated forces."[26] The regulation listed drawbacks to radios use as interception by the enemy, therefore the need for ciphers, and hostile interference.[27] The Army saw a need for

radio, but as an alternate and secondary means to wire communication. During this same period, the commercial communications industry grew exponentially, especially in the field of radio. The formation of the Radio Corporation of America (RCA) in 1919 helped lead this explosion in radio communication technology.[28]

Technological advances in radio during this period included the move from spark-gap method to continuous wave with the introduction of vacuum tubes. These advances led to the rapid spread of radio, including broadcast music and news.[29] These innovations led to the proliferation of radios in homes, ships, and by 1931, cars.[30] A leader and visionary in the field of radio was David Sarnoff, a Russian Jewish immigrant who by 1921, at the age of 30 had worked his way up to become General Manager of RCA.[31] Sarnoff was instrumental to the U.S. Army and Navy during World War I while working for Marconi Wireless Telegraph Company and had a keen sense of the future impact of radio technology. Sarnoff was a world leader in the field of communications technology and received a Lieutenant Colonel's appointment in the Signal Corps Reserve in 1924.[32]

The Vision of Radio in the Army - Visionaries vs. the Status Quo

Major Harry C. Ingles, a Signal officer in the USAWC class of 1932 and future Chief of Signal, was a strategic thinker who developed a vision for the use of radio in the Army. Ingles, who served stateside during World War I, envisioned improved radio communications for a future force structure with wheeled and tracked vehicles.[33] In World War I, infantry divisions fought on foot, and during the 1930s, a debate raged within the combat arms on the organization and location of tanks and armored vehicles.[34] The goal was to determine how these forces would communicate.

Major Ingles' 1932 Army War College paper and subsequent *Signal Corps Bulletin* article "Command and Signal Communications to and within Mechanized Units", envisioned future tank formations using radiotelephones to communicate over radio, instead of the standard radiotelegraphy, which was telegraph over radio.[35] The main advantage of radiotelegraphy was greater range over the radiotelephone, but tank operators needed to know Morse code, which was a slower means of communication than voice. It was also essential for the tank to halt in order to communicate because radio operators were unable to transmit or receive messages during movement. Major Ingles also envisioned designing space in tanks specifically for radio equipment.[36]

Although Major Ingles advocated additional means of communication, such as semaphores, disks, flags, and pyrotechnics, radio allowed mobile units to communicate most effectively.[37] He recommended that platoon commander's vehicles have two-way radios and the other vehicles have one-way receivers.[38] Ingles identified the requirements for these units needing radios capable of communicating not only to their higher headquarters, but also to aviation and infantry units. He addressed this issue due to the limitations of the existing amplitude modulation (AM) radios and the impact motor vehicles had on certain ranges within the frequency spectrum.[39] Vehicles and airplanes, which operated with internal combustion engines, caused a great deal of static on their AM radios.[40]

During this period of uncertainty in the future organizational structure of the Army, General Irving J. Carr (USAWC Class of 1921), the Chief of Signal from 1931-1934, influenced the Signal Corps vision for radio's use in the Army.[41] Major General Carr provided his vision for the future of radio in the combat arms during a lecture to the

Army War College in November 1932.[42] During the lecture, Carr mentioned that the Army had to provide radio to the Air Corps. He said, "…we will sacrifice radio from a division to a brigade of infantry, or from a brigade to a regiment, if we have to, in order to give the Air Corps radio."[43] Carr later stated that, "The air is jammed [with frequencies], but on the other hand, radio science is improving and they are able to straighten out and narrow down the radio waves by the excellence of instruments [new equipment]." He also stated, "So it would be hard to say right now what the general result 10 years from now will be. But the trend is now to put the lid a little on the indiscriminate use of the radio in the field."[44] *The Signal Corps Bulletin* published this lecture in its January-February 1933 edition.[45]

Major General Carr's view on the future use of radio in the Army for the combat arms was clearly limited and shortsighted. Although Carr saw the need for radio communication with aircraft, his vision was inadequate on its expansion with ground troops. He knew there were technical limitations on the current AM radios, and therefore advocated to "put a lid on the indiscriminate use of the radio in the field."[46] Major General Carr's service in World War I earned him the Silver Star and the Purple Heart for action in France as the Chief Signal Officer for the 2d Division, IVth Corps, and Third Army.[47] Carr's "status quo" vision of communications support for the combat arms in the next war was due to his great reliance and experience using field wire during World War I.

Around this same time in the early 1930s, inventor and Columbia Professor Edwin Armstrong began experimenting on how to improve radio technology and made a discovery that forever changed the face of radio. After the World War, Armstrong

remained a reserve signal officer and began focusing on the possibility of frequency modulation (FM) radio.[48] Amplitude modulation was the first means discovered to carry a voice signal on top of a carrier signal, where the strength of the carrier wave changes in sympathy with the transmitted frequency. At the time, AM was the standard method used in radio. Armstrong's FM was simply another method for carrying a message signal imprinted on another carrier signal on a set frequency.[49]

Edwin Armstrong brought vision and technology together to make FM radio viable and by 1934, submitted a series of patents on his invention. In 1935, Armstrong presented his new technology to an audience of radio professionals in New York, demonstrating the high fidelity sound of FM radio.[50] Armstrong's invention of FM radio had great military application, because it was not as susceptible to static caused from internal combustion engines.[51] The commercial sector did not initially embrace this new technology because of its impact on the existing AM radio market. Armstrong's invention did not upgrade AM radios; it made them obsolete.[52]

The same year that Armstrong demonstrated the viability of FM radio, another group of Signal Corps strategic leaders presented their vision of the future of radio in the Army. Colonel Arthur S. Cowan, USAWC class of 1927, and the Commandant of the Signal School, delivered the lecture "Development of Signal Communications" to the Army War College on September 19, 1935.[53] Strategic leaders need to stay connected to visionaries, both inside and outside their organizations, in order to develop a vision for the future.

Within the Signal Corps, strategic leaders like Colonel Cowan needed to stay in touch with those in industry like Armstrong who were breaking new ground and pushing

the envelope of existing technology. During the lecture, Cowan presented his limited vision on the future use of radio when addressed the question of “What is the Signal Corps solution to the disproportion between the number of radio sets to be taken into the field and the much smaller number of radio frequencies available in the [frequency] spectrum?” [54] His opinion was the Signal Corps was reluctant to tell other branches “what they shall have [amount of radios] or what they shall do [how to employ them].”[55] Cowan exhibited frustration with certain branches wanting more radio when he said, “It seems to me that if informed people of mature judgment would examine this situation they would see that we are going too far with radio.”[56] He later said, “People are just going crazy with it [radio].”[57] The combat arms request for more radios and the Signal Corps lack of a technical solution to provide more frequencies exasperated him. Cowan also said, “Every fellow cannot have a radio set…” and “The cavalry want a radio on the outside of a horse and the Infantry want radio on the inside of armored cars and tanks.”[58] The combat arms realized that radio was the only viable means for command and control to the mechanized and motorized forces of the future.

The doctrinal status of radio as a secondary means of communications was reinforced by Major General James B. Allison, the Chief of Signal from 1935-1937, when he presented his “status quo” vision of radio’s future during the same lecture.[59] He said, “I think we consider the radio as a standby channel of command.” Major General Allison believed that when the division or corps commander issued an order, they needed to “silence all radios except those between plane and the ground and between headquarters and fast moving elements out to his front.”[60] He argued that in combat,

when wire lines are disabled, the signal officer could authorize the use of radio until the restoration of the wire lines.[61]

Here is an example of two senior Signal Corps strategic leaders, in 1935, falling back on the experiences of the Great War, where wire was the primary means of communication within the Army. Colonel Cowan saw action in World War I and was the recipient of the Purple Heart.[62] Although Major General Allison did not see service in France during the war, he was involved in the training of troops for overseas duty.[63] Both strategic leaders fell back on the institutional knowledge of the Army, which directed that wire was the primary means of communication in battle. Wire was still the Army's primary means of communication based on the 1923 *Field Service Regulations*. Leaders based their opinion on the technical capability of existing AM radios and the collective experience of the Signal Corps and Army in World War I. Yet, as previously described, by 1934 - 1935, Armstrong had demonstrated the principles of FM radio, which provided high fidelity sound and significantly reduced the amount of static produced by internal combustion engines and tracked vehicles.[64] Frequency modulation, coupled with the use of ultra-high frequency (UHF) range (discussed later), demonstrated the future expansion of the frequency spectrum for military use.

Major General Allison's experiences from the World War and post-war Army influenced his limited vision for radio. He used the pages of *The Signal Corps Bulletin* to convey his vision for the future of radio to senior strategic stakeholders and subordinates. In these articles, Allison was consistent in his repetition of the limited role of radio in the Army. In two articles published in 1936, Allison espoused his belief that the Army had too much radio and that wire was a better choice for communications.

Although he saw the need for radio within mechanized and horse cavalry, for most units, radio was “merely a contingent or an auxiliary means to be resorted to when their wire systems have failed or before they are put in.”[65] Allison also wrote, “It is a well accepted fact…that main reliance on communications to ground troops must be placed on wire lines, with radio as an alternate means.”[66] Here are two examples of the Army’s Chief Signal Officer, communicating his limited vision for the future use of radio to his subordinates and senior strategic leaders.

Major Generals Carr and Allison were reluctant to see radio as anything but a secondary means of communication because they did not envision a technology that enabled radio to serve such a vital role in the next war. They were creatures of their past and wedded to the lessons of the Great War. The experiences of the World War gave these senior strategic leaders their institutional knowledge and reliance on wire. *Infantry in Battle*, first published in 1934, and later in 1938, reinforced this institutional attachment to wire communications. The purpose of the book, as described by Colonel George C. Marshall, was, “to give the peace-trained officer something of the viewpoint of the veteran.” Marshall went on to say, “The aim of its authors has been to develop fully and emphasize a few important lessons which can be substantiated by concrete cases rather than to produce just another book of abstract theory.”[67] In Chapter XIII: Command and Communication, the examples used from World War I battles utilize wire communication and runners in depicting proper command and control within the infantry battalion.[68] The Infantry School looked back on the previous war, reinforcing the lesson that wire was the primary means of communication in battle. The current Army doctrine,

found in the 1923 *Field Service Regulations*, reinforced this reliance on wire, while visionaries sought the technical solution to reliable radio communications for the Army.

The appointment of a new Chief of Signal with a technical background in radio brought some change to the Signal Corps' vision of radio in the Army. During World War I, Major General Joseph O. Mauborgne served in the Office of the Chief Signal Officer, where he was involved in the development of radio, wire, and cipher equipment. He also served in the branch's engineering and research division and later as the Director of the Signal Corps Aircraft Radio Laboratory.[69] While there, he was instrumental in the continuing development of radar (Radio Detection and Ranging) and went on to serve as Chief Signal Officer from 1937 through 1941.[70]

Major General Mauborgne knew that the radios fielded by the Army, especially those designated for the combat arms, were inadequate. During a lecture delivered to the Army War College in 1938, he addressed the constraints of the availability of radio frequencies in the spectrum.[71] He admitted that the frequency spectrum was currently "too small", but the Signal Corps was working on power issues, and overlapping frequency bands so units would not jam one another.[72] Mauborgne stated, "The services are all crying for more frequencies, particularly the Mechanized Force."[73] He went on to say the Signal Corps was doing what it could, but "I don't see where we are going to get any more frequencies."[74] He also complained about the bureaucracy, red tape, and lag time that the Signal Corps endured in order to design and build radios for Army requirements.[75]

Major General Mauborgne also addressed radiotelephone use within the division. He argued that the Signal Corps was fielding a good system, but the main problem was

that only two stations could access the net on a frequency and that radiotelephone used too much bandwidth. Additionally, voice over radio enabled the enemy to listen in due to radio's lack of encryption.[76] Mauborgne also spoke about crystals, which was a new means in technology to stabilize the radio's frequency. A crystal-controlled radio locked the frequency in place and did not require tuning, which was critical in a moving vehicle.[77] He mentioned that crystals were important, and the military was securing access to the raw material in Brazil.[78] Mauborgne realized the value of technology and supported the move toward radio innovation. Crystal controlled radios became one of the crowning achievements of the Signal Corps in World War II.

Major General Mauborgne's vision for radio in the Army was more robust than his predecessors, yet still conservative and not did fully embrace the requirements of the combat arms for better on-the-move communications. He was aware of the technical issues facing radio in tanks and vehicles, yet was slow to embrace the technology to solve them. During the lecture, Mauborgne also addressed shielding and bonding radios in combat motor vehicles to reduce the amount of static and working with the amount of power needed to transmit a message while moving.[79] His comments show that he envisioned improving existing radios, but it did not expand his vision to embrace a new technology like FM. By this time, strategic leaders and thinkers from industry were moving toward viable technological solutions to the Army's problems of static interference and congestion in the AM radio frequency range.

At this point, the Army was beginning to modernize after a long period of little growth and reduced budgets. The Army finally updated its warfighting manual, unmodified since 1923, in the 1939 *Tentative Field Service Regulations, Operations, FM*

100-5. In describing the Signal Corps and its functions, it stated that, “wire transmission (telephone, teletype, and telegraph) constitutes the basic means of signal communication.” It went on to say that, “Other means of communications supplement and extend the service of the wire circuits.” It also said that radio was useful during movement, but must be “silenced for tactical reasons or restricted because of congestion of frequency bands.”[80] Here we have the Army clearly limiting the use of radio due to the issues inherent with AM radio. Frequency modulation technology was going to change this paradigm and allow the rapid expansion of radio for use by the Army at war. The updated 1941 *Field Service Regulations, Operations* used similar language to the 1939 edition. It stated, “Wire communications (telephone, telegraph, and telegraph printer) constitute the basic technical means of signal communication for the infantry division and the larger unit headquarters.”[81] It went on to say that radio communications was, “especially applicable in spanning distances between widely separated mobile forces, between ground and air, and in the fire-swept zone of the forward area.”[82] It also lists the vulnerabilities of radio as static, hostile interference, interception and location.[83] The Army’s doctrine still called for wire, with radio serving as a secondary system and primary for the growing Armored Forces. Doctrine clearly showed the lack of confidence the Army had in radio communication as late as 1941.

The Signal Corps and industry knew of Edwin Armstrong’s accomplishments and success with FM radio. An article “Frequency Modulation Demonstrated” in the July-September 1939 edition of *The Signal Corps Bulletin* covered Armstrong’s demonstrations conducted in late 1938 and 1939. The article highlighted FM radios major qualities, which were high fidelity and elimination of static (extremely low signal to

noise ratios).[84] By this time, the radio industry had slowly begun to accept his new technology, resulting in General Electric building two FM transmitters and selling FM receivers.[85]

The Signal Corps leadership, including Major General Mauborgne, was aware of these experiments in the fall of 1938 but there was internal dissent within the Signal Corps radio engineers on the pros and cons of FM versus AM radios. Lieutenant Colonel Hugh Mitchell, the Director of the Signal Corps' Aircraft Radio Laboratory, was involved in the fall 1938 demonstration and embraced the value of FM radio. The ability to reuse frequencies, allow multiple nets on the same frequency, and very low noise and interference were qualities desperately needed by the Signal Corps.[86]

In the same journal that published "Frequency Modulation Demonstrated", Captain Komnenus M. Soukaras wrote an article on "Signal Communication and the Ultra High Frequencies", which described how "rapid motorization" of armies had changed the paradigm on how fast communications needed to occur.[87] Coincidently, publication of this this article occurred with the German invasion of Poland on September 1, 1939, which initiated the start of World War II. Soukaras said that with the advent of fast moving armies, radio was the only means to support them. He went on to advocate the UHF range, a part of the frequency spectrum which had previously been unused by the military. This range of frequencies offered multiple parties the use of one frequency, a benefit over existing AM radios, which limited two stations on one frequency. The UHF range also had the benefit of a limited transmission range, which aided in the enemy not picking up transmissions since it was not encrypted.[88]

War in Europe and the speed of German victory in Poland were on the mind of students when Major General Mauborgne briefed the Army War College in late September 1939.[89] After a lecture on the Signal Corps' wartime mobilization, Major General Mauborgne addressed a question on what he had learned about the German advance into Poland. The German reliance on radio during its rapid advance of 30-40 miles a day, over the use of motorcycles and air messages was of major interest.[90] Major General Mauborgne said that the German radios in their tanks and combat cars were, "probably all motorized outfits, just as we will have to have in the army in the streamlined divisions." He also stated, "I think the majority of that stuff has been primarily with moving forces by mechanized or motorized radio sets."[91] The German mechanized forces, under the leadership of Heinz Guderian, who had served as a Signal officer in World War I, embraced the need for tank communication doctrine and included two-way radios in each of their tanks.[92] Mauborgne realized the criticality of radio, based on his involvement in its development for the previous twenty years and the reality of mobile warfare. Yet he was slow to accept FM technology because of a lack of substantive proof of its improved qualities. He was also risk adverse due to resource constraints, manufacturing capacity, and competing programs, such as radar development.[93]

The demonstrations conducted by Edwin Armstrong, now a Major in the Signal Corps Reserve, coupled with Germany's successful invasion of Poland, expedited the move forward on procuring new radio technology for the Army.[94] The war and FM radio's potential capabilities led to action by the Signal Corps Laboratories, under the direction of Colonel Roger B. Colton (USAWC class of 1938), who took charge as

Director in 1938.[95] Colton was a strategic leader who envisioned better equipment to support the growing Army and guided the Signal Corps Laboratories to work with Professor Armstrong to develop the first push button, crystal controlled, FM tactical radios. Armstrong gave his time, equipment, and the free use of his patents in order to make the project successful. The Army awarded Armstrong a Legion of Merit in 1946 for his efforts in support of the Signal Corps.[96]

The growing and modernizing Army's need for improved communications for ground, mechanized and air forces was reaching a critical stage. In October 1939, the Signal Corps Laboratories procured a number of untested and prototype radio systems, utilizing UHF, crystal control, and an untested police department FM set built by Armstrong and conducted a demonstration for the Mechanized Cavalry Board at Fort Knox, KY.[97] Although the demonstrations showed FM radio had some advantages over the existing AM radios, it was not conclusive.[98] Yet, FM radio's ability to solve the two main problems facing the Signal Corps, a lack of frequencies in the AM range, and static interference caused by combustion engines required further investigation and testing.[99]

The Signal Corps had mixed feelings on FM technology due to its experimental and unproven status, yet the Army's combat arms wanted and needed more radio.[100] There was a requirement and the Signal Corps' job was to provide the Army with a proven and reliable capability. Edwin Armstrong and the Signal Corps Laboratories made improvements in the technology and within the next year, the Signal Corps embraced the FM radio as a solution for vehicular radios.[101] While the Signal Corps was

searching for a reliable radio that could operate in a vehicle, it was also dealing with the development and funding of radar.

Radar research received the majority of funding at the Signal Corps Laboratories, to the detriment of ground radio development.[102] As far back as 1936, Major General Allison sought additional resources and diverted funding from other projects toward radar development.[103] The bill payer for the Signal Corps' research and development was from tactical communications. By 1939, the Signal Corps was allocating a large amount of its research budget towards radar development, a top secret and higher priority over newer and more capable radios.[104] Thus, risk aversion and prioritization led the Signal Corps leadership to allocate more resources toward radar than tactical radio development.

As the Signal Corps leadership was finally beginning to embrace a more robust vision of radio in the Army, David Sarnoff, now RCA's President, presented a glimpse of the future in the March-April 1940 issue of *The Signal Corps Bulletin*. Sarnoff clearly articulated his vision for the future of radio: "in mobile communications, the use of ultra short waves should make it possible for vehicles on land, in the air, and on the water to establish and maintain contacts with anyone, anywhere."[105] He went on to say, "It is possible to extend the uses of radio so that individuals may carry "pocket radios" and be able to receive messages and programs wherever they may be."[106] Here was a vision of ubiquitous communications, an example of Kotter's "imaginable picture of the future."[107] This vision, which was years ahead of implementation, shows how strategic leaders must look forward, and not back, when, envisioning the future.

The war in Europe energized the Army to begin critically needed expansion and modernization. In May 1940, the Army conducted a large corps and army training exercise along the Texas and Louisiana border that involved more than 60,000 Soldiers and put to the test its tactical communications equipment. The maneuvers showed that the Signal Corps' wire and radio equipment was inadequate and "proved deficient" in supporting command and control to the Army.[108] The SCR-197, a vehicle-mounted long-range AM radios could only work once the vehicles were stationary, antenna set up and a generator started for power. The new triangular divisions even lacked the frequencies for their existing and outdated AM radios.[109] The divisions needed crystal controlled FM radios that were not yet in production for the growing U.S. Army. While the Army struggled to communicate during these exercises, the German Army was roaring through France using the combined arms attack known as "blitzkrieg".[110] According to Major General F. W. Von Mellethin, a German participant in the attacks, "the up-to-date wireless equipment of our armored units gave them a clear advantage in maneuver."[111] The need for viable radios in the Army's combat arms could not have been greater. By late 1940, the Signal Corps embraced the FM radios for the Infantry, Artillery, and Armored Forces.[112] This acceptance validated the visionaries from within the Signal Corps and industry who envisioned a large role for radio in the next war.

Radio provided a reliable and easy means of communication for the Army's ground, mechanized, and air forces in World War II. The Signal Corps fielded small, reliable radios to the squad and platoon levels in increasing numbers. By 1942, the Army fielded the SCR-300 "walkie-talkie", which was a 35 lbs. backpack carried FM radio with a two-mile range. The Signal Corps also had the SCR-536, the "handie-

talkie", an AM radio built for the infantry squad that weighed only 5 lbs. The Armored Force and the Field Artillery also had FM radios for internal communication and infantry-artillery coordination.[113] In the words of an infantry radio operator during the war, "FM saved lives and won battles, because it speeded our communications and enabled us to move more quickly than the Germans, who had to depend on AM."[114] He also said, "One of the main reasons the American Army moved so fast against the Germans was that it had over-all information supplied by fast communications. In combat teams, that meant radio, and that radio meant FM."[115] The development and production of FM radios literally occurred just in time for the U.S. Army. These radios, which provided crystal control, static free clarity, aided in the effectiveness of combined arms warfare and helped ensure victory.

Television for Military Use: A Paradigm for Envisioning the Future

A better example of how to envision the future and pursue technological change during an era of reduced resources was the vision of military use of television. Again, one of the early visionaries of television was David Sarnoff, who presented a vision for the future role of radio and television, which was just in the experimental stage, to the Army in early 1927. Sarnoff said, "Far away as we may seem from the accomplished fact of television by radio, we have made sufficient progress to bring the goal to measurable distance."[116] He concluded, "When that stage is reached, our considerations of the problems of television can well turn from fantasy to fact."[117] Sarnoff had a strategic vision for television, broadcast over radio, which had possible military application. In the near future, others would add clarity and substance to this vision.

While the nation was in the grips of a devastating depression, visionaries within the ranks were examining television and its military application. An example of a

visionary was Captain Stephen H. Sherrill, a Signal Corps officer (USAWC Class of 1939) who in 1932 wrote on the "Possible Application of Television to Military Signalling [sic]" while attending the Command and General Staff School's Second Year Course at Fort Leavenworth, KS.[118] Sherrill noted that television was new, but had great military application. He described the ability of one day having television in a plane or on the ground transmitting a picture of terrain back to the command post for the commander to evaluate.[119] Sherrill's vision advocated for further government investment and experimentation with industry to exploit this new technology.[120]

Envisioning the future use of television was not only the purview of the Signal Corps. Another strategic thinker in the class, Major Edwin C. Mead, a Coastal Artillery officer, also wrote about the military use of television in "A Detailed Study of the Possible Military Uses of the Science of Television".[121] Mead contacted multiple industry leaders in television, including the president of RCA, David Sarnoff (now a Colonel in the Signal Corps Reserve) about the military use of television.[122] Mead envisioned placing television in an airplane and having it fly over enemy territory to study terrain, keep track of friendly troops and adjust artillery fire.[123] Here is an example of a strategic thinker providing a more detailed vision of the military use of television and seeking the help of strategic leaders of industry.

Visionaries within industry, which was leading the research and development of television, were continuing to refine their visions on its military application. A year after Sherrill and Mead wrote their papers; David Sarnoff lectured to the Army Industrial College, where he offered his vision of the future of communications. He said, "Radio has already demonstrated its advantage over the cable" and "Both television and

facsimile transmission may have the most vital bearing on our future communication methods…and the national defense."[124] He went on to say, "It would be of much benefit…if the War and Navy Department from time to time would assign capable communication engineers to the research laboratories of the American Communication Companies…" Sarnoff envisioned "a double value from such assignments."[125] That double value was keeping abreast of the latest communication technologies and steering it toward military application. Sarnoff was advocating further development and investment by the government in these areas of communication, as he envisioned a use greater than just entertainment.

Industry continued to refine, develop, and expand its vision of television and its potential military application. In 1933, James G. Harbord (Major General Retired), Chairman of the Board for RCA and former chief of staff of the AEF in World War I, gave a speech, "Radio in War", where he laid out a vision for the military use of television.[126] Harbord described the future, when radio and television technology would provide, "fantastic possibilities – the radio-piloted plane carrying television apparatus which will place on a screen before commanding officers a moving picture of their advancing troops and the enemy territory into which they are advancing."[127] The vision itself was a premonition of the yet to be invented Unmanned Aerial Systems currently in use today.

Similar to innovations in radio technology, Army strategic thinkers and leaders were also staying abreast of the latest television research and development in order to refine their visions. In April 1934, while lecturing at the Army War College, Major George L. Van Deusen, Signal Corps, (USAWC Class of 1936), responded to a question about

the military use of television.[128] Van Deusen felt that the technology was not mature enough, but there were some military applications for it, such as placing it in an aircraft and transmitting pictures down to a ground station.[129] Similarly, the Office of the Chief of Signal was staying abreast of television's development. In 1937, Major William S. Rumbaugh (USAWC Class of 1934) said the Signal Corps had a television project in their laboratory and they were closely watching industry to see if there was any military application to the technology.[130] He mentioned that RCA had received a $100,000 contract with the Russian government to produce a set mounted in an airplane along with corresponding ground equipment.[131] Rumbaugh reported that due to poor results Major General Mauborgne determined that television did not currently have military application and the Signal Corps was letting industry spend their money on development.[132] These comments show good communication between strategic leaders and thinkers within the Signal Corps and industry. It was critical that the Signal Corps stay abreast of industry's research and development, and their vision for the future. During a period of reduced budgets, the Signal Corps was correct in monitoring progress to see if television had military application. This was a lesson learned by the Signal Corps and applied to envisioning the use of new and untested technology.

The vision for the military application of television continued to develop as senior strategic leaders within the Signal Corps embraced the idea. Five years after he addressed television's use in the Army, now Colonel Van Deusen wrote "Television and its Possible Military Applications" in *The Signal Corps Bulletin*.[133] In this article, Van Deusen presented a more detailed vision for the future use of television on the battlefield. He gave four applications for its future use: Aerial observation; Adjustment of

artillery; Aiding in radio control of unmanned craft and Mass propaganda.[134] Although Van Deusen realized that this vision was futuristic and wrought with technical problems, it was possible. He realized that until the government placed contracts with industry, there was no financial incentive.[135] Somewhat different from what occurred with FM radio technology, here a Signal Corps strategic leader advocated for government funding to improve technology for military application.

These civilian and military strategic leaders and thinkers envisioned the future in order to prepare for the next war. They looked at the current state of affairs and envisioned something different in the future. In this case, it was strategic leaders and thinkers from industry and the Army who envisioned the future military application of television. Although their vision was years ahead of technology or practicality, they were pushing forward, looking for the future in the present times. It appears that the senior leadership of the Signal Corps embraced this vision but did not pursue it due to fiscal constraints and practicality. The military use of television is a good example of strategic leaders envisioning the future. The Signal Corps not only looked internally, but also externally for visions on what the future would look like.

Conclusion

The challenges facing the Signal Corps in the 1930s are applicable to today's Army as we enter a fiscally constrained environment. The first and most important lesson is that the Signal Corps must build a clear vision for the future and communicate that vision to key stakeholders within the Army and industry. Strategic leaders navigating the VUCA environment need to diligently create and build a vision for their organization's future. The leader competency of envisioning the future is critical in order to help an organization chart its course. As senior strategic leaders, we need to

recognize this and spend time and energy refining our vision for the future and working with key stakeholders to reach our desired end state.

The Signal Corps in the 1930s had a mixed vision when it came to the future support of the Army in the next war. The Chiefs of Signal envisioned that wire was still the primary means of communication within the division. This vision was different from those presented by strategic leaders and thinkers within industry and the Signal Corps. It was clear that the combat arms demanded more radios because they needed to be free from wire. Signal Corps strategic leaders should have aggressively sought a technological solution to provide radios that were more effective to the Army. As early as 1935, Edwin Armstrong demonstrated that FM worked. This, coupled with the expansion of the UHF range of the frequency spectrum, helped expand the use of radios in the combat arms. As it turned out, radio played a crucial role in supporting the combat arms during World War II, from the “walkie-talkie”, “handie- talkie”, and the FM radios used by the armored forces, infantry, and artillery.

Another lesson is that we tend to fall back on our experiences; institutional knowledge is hard to change. The senior Signal Corps strategic leadership in the 1930s was comfortable with the doctrine of wire as the primary means of communications within the infantry division. They embraced the need for radio in mechanized and aircraft units, but insisted it serve as a secondary means of communication for all other forces. They based this on their first-hand experiences learned in France during World War I and through years of training in the post-war Army. Wire was the primary means of communication, espoused in *FM 100-5 Operations*, which described how the Army would fight. Yet the combat arms branches demanded more and more radios. The

Signal Corps' leadership reluctantly provided them, but knew there were issues with the congestion of radios to frequencies and problems with static interference when vehicle mounted. There is nothing wrong with experience, especially when gained in combat. Yet, strategic leaders need to identify changes in their environment to prepare for the next war. The Signal Corps' leadership held to wire communication when strategic leaders and thinkers within the branch and industry had demonstrated that the technology existed for improved radios, especially for those mounted in vehicles.

The Signal Corps must work closely with industry to seek new technologies and test them as they become available. The introduction of the semi-annual Network Integration Exercise (NIE) conducted at Fort Bliss, TX appears to be the right environment for this. The Program Executive Office, Command, Control, Communications - Tactical is responsible for the NIE and quickly integrates and tests new technology in an ongoing experiment in the field.[136] This is very different from the demonstrations conducted by the Signal Corps for the Mechanization Board in 1939. The Signal Corps needs to evaluate and test new technology before embracing it. However, they need to have open minds and to lean forward in order to best support the Army's requirements. Having Soldiers test the latest communication technologies in the field prior to major acquisitions is a great strategy. This will only aid the Signal Corps to test and integrate new technologies as they become available.

The Signal Corps needs to strengthen its ties with industry by using direct commissions to bring select communication engineers and scientists into the Army as Signal officers in the U.S. Army Reserve. Uniformed technical specialists in the ranks who can serve the Chief of Signal or the Army Staff's Chief Information Officer/G-6 can

only strengthen the Signal Corps. When World War II occurred, strategic leaders from industry were able to quickly transition onto active duty to assist the Signal Corps. David Sarnoff mobilized numerous times to advise the Chief of Signal on advisory councils and troubleshoot communications issues around the world. This included tours supporting General Eisenhower's staff in Europe and led to his promotion to Brigadier General.[137] Another example of ties with industry was Edwin Armstrong giving his time, effort, and the free use of his patents to assist the Signal Corps Laboratories in perfecting FM radios for use in the Army.[138] In order to strengthen the Signal Corps, a cooperative relationship with the best and brightest from industry and academia must exist and be supported. However, there are other programs, which can also support this goal of learning and working with industry.

The Signal Corps must continue to support the Training With Industry (TWI) program. In TWI, Soldiers work directly with industry partners for a set period, in order to, "improve the Army's ability to interact and conduct business with industry." The benefit of TWI to the Army is for Soldiers to be, "exposed to innovative industrial management practices, techniques, procedures, etc., which have applicability to, and benefit for, the Army."[139] Working closely with industry partners also supports our government's 2010 Quadrennial Defense Review, which states, "America's security and prosperity are increasing linked with the health of our technology and industrial bases." It goes on to say that, the Department of Defense clearly sees the need for, "a strategy that better accounts for the rapid evolution of commercial technology…"[140]

Another lesson from this period is that when the Signal Corps has multiple competing technologies vying for funding in a resource-constrained environment,

someone will lose. The funding for radar overshadowed ground and aircraft radio development, which was partially responsible for the slow acceptance of radio by the Signal Corps' leadership. To keep this from happening in the future, Signal leaders must prioritize their requirements. Clearly, in the 1930's, radio was a priority for an Army moving toward motorization and mechanization. The Signal Corps could not ignore that fact and needed to make radio development for the combat arms a priority. The Signal Corps staying abreast of industry's work with television is a good model to use when technology is still in its infancy and resources are constrained. The Signal Corps must be judicious in where it spends funding, but its leaders cannot be so risk adverse that they do not embrace new technology, which adds capability and meets Army requirements.

What does the future hold for the Signal Corps? In the last 100 years, radio technology has moved from spark-gap to vacuum tubes to transistors, from simplex to full duplex voice and data circuits over wire, radio, and satellite. Voice over radio has gone from analog, to digital, and now to IP (internet protocol). The blending of cyber and radio with the advent of Everything over Internet Protocol (EoIP) will cause the Signal Corps to re-evaluate its vision for the future. The vision of EoIP is an IP network carrying all applications and services, from voice, video, and data.[141] The Signal Corps needs to work closely with the Training and Doctrine Command to identify requirements and the Acquisition Corps and industry to identify the future vision of communications support for the Army.

Endnotes

[1] Stephen J. Gerras, eds., *Strategic Leadership Primer* (Carlisle Barracks, PA: Department of Command, Leadership and Management, U. S. Army War College, 2010), 2.

[2] Leon E. Panetta, "Willing to Make That Fight," *Army Magazine*, (December 2011): 36.

[3] Stephen J. Gerras, eds., *Strategic Leadership Primer*, 30, 33.

[4] U.S. Department of the Army, *Army Leadership*, Field Manual 6-22 (Washington, DC: U.S. Department of the Army, 12 October 2006), 12-2.

[5] John P. Kotter, *Leading Change* (Boston, MA: Harvard Business School Press, 1996), 67.

[6] Rebecca Robin Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington, DC: Center of Military History U. S. Army, 1999), 241.

[7] Kotter, *Leading Change*, 72.

[8] Brian McAllister Lynn, *The Echo of Battle, The Army's Way of War* (Cambridge, MA: Harvard University Press, 2007), 117; Hermine Scholz and Richard J. Sommers, *Special Bibliography 20, Volume I, World War I Manuscripts, The World War I Survey* (Carlisle Barracks, PA: U.S. Army Military History Institute, 1986), 1.

[9] Raines, *Getting the Message Through*, 241.

[10] Dulany Terrett, *The Signal Corps: The Emergency* (Washington, DC: Office of the Chief of Military History, 1956), 141.

[11] Gerras, eds., *Strategic Leadership Primer*, 23.

[12] U.S. Department of the Army, *Army Leadership*, 12-3.

[13] Terrett, *The Signal Corps: The Emergency*, 18-19.

[14] Ibid., 18-19.

[15] Ibid., 18.

[16] Raines, *Getting the Message Through*, 185.

[17] Terrett, *The Signal Corps: The Emergency*, 16.

[18] Ibid.

[19] "General Carty Passes On," *The Signal Corps Bulletin* no. 71 (March-April 1933): 38.

[20] Raines, *Getting the Message Through*, 170-171.

[21] Terrett, *The Signal Corps: The Emergency*, 19.

[22] Raines, *Getting the Message Through*, 217-221.

[23] Terrett, *The Signal Corps: The Emergency*, 29-35.

[24] Chief of Staff of the Army, *Field Service Regulations United States Army 1923*, (Washington, DC: Government Printing Office, 1924), prologue (cover sheet).

[25] Ibid., 29-30.

[26] Ibid., 30.

[27] Ibid.

[28] Raines, *Getting the Message Through*, 225.

[29] Ibid.

[30] Eugene Lyons, *David Sarnoff* (New York, NY: Harper & Row, Publishers, 1966), 124.

[31] Ibid., 21, 104.

[32] Ibid., 40, 77, 78, 223.

[33] Raines, *Getting the Message Through*, 261.

[34] Harry Yeide, *Steeds of Steel: A History of American Mechanized Cavalry in World War II* (Minneapolis, MN: Zenith Press, 2008), 26; Kent Roberts Greenfield, Robert R. Palmer, and Bell I. Wiley, *The Army Ground Forces: The Organization of Ground Combat Troops* (Washington DC: Historical Division, Department of the Army, 1947), 56-57.

[35] Harry C. Ingles, *Command and Signal Communications to and within Mechanized Units*, General Staff Memorandum (Fort Humphreys, DC: U.S. Army War College, February 18, 1932), 1. General Staff Memorandum were student Strategy Research Projects in the 1930s; Harry C. Ingles, "Command and Signal Communications to and within Mechanized Units," *The Signal Corps Bulletin* no. 68 (September - October, 1932): 1-11.

[36] Ibid., 2, 3.

[37] Ibid., 4.

[38] Ibid., 2.

[39] Ibid., 8.

[40] Terrett, *The Signal Corps: The Emergency*, 142.

[41] "The new Chief Signal Officer," *The Signal Corps Bulletin* no. 62 (September-October, 1931): 4.

[42] Irving J. Carr, "The Influence of the Control of International Communications on the Conduct of War," briefing slides with scripted commentary, Fort Humphreys, DC, U.S. Army War College, November 10, 1932. 21 pages plus 3 pages of questions and answers (Q&A).

[43] Ibid., 1. Q&A

[44] Ibid., 2. Q&A

[45] Irving J. Carr, “The Influence of the Control of International Communications on the Conduct of War,” *The Signal Corps Bulletin* no. 70 (January-February, 1933): 2-17.

[46] Irving J. Carr, “The Influence of the Control of International Communications on the Conduct of War,”, 2. Q&A

[47] The Adjutant General’s Office, *Official* Army *Registry, January 1, 1940*, (Washington, DC: U.S. Government Printing Office, 1940), 949; “The new Chief Signal Officer,” *The Signal Corps Bulletin* no. 62, 4; Raines, *Getting the Message Through*, 235.

[48] Yannis Tsividas, “Edwin Armstrong: Pioneer of the Airwaves,” http://www.ee.columbia.edu/misc-pages/armstrong_main.html?mode=interactive (accessed September 28, 2011).

[49] John Graham, *The Facts on File Dictionary of Telecommunications* (New York, NY: Facts On File, 1991), 6, 68.

[50] Yannis Tsividas, “Edwin Armstrong: Pioneer of the Airwaves,”. Armstrong’s presentation was to the International Radio Engineer conference in New York.

[51] Terrett, *The Signal Corps: The Emergency*, 142.

[52] Yannis Tsividas, “Edwin Armstrong: Pioneer of the Airwaves,”.

[53] Arthur S. Cowan, “Development of Signal Communication,” briefing slides with scripted commentary, Fort Humphreys, DC: U.S. Army War College, September 19, 1935, 1-9, 4 pages of question and answer. Also published in *The Signal Corps Bulletin* no. 89, March-April 1936.

[54] Ibid., 2. Q&A

[55] Ibid.

[56] Ibid.

[57] Ibid.

[58] Ibid.

[59] Raines, *Getting the Message Through*, 236; Cowan, “Development of Signal Communication,”.

[60] Ibid.

[61] Ibid.

[62] The Adjutant General’s Office, *Official Army Registry, January 1, 1940*, 966.

[63] Raines, *Getting the Message Through*, 236; “Appointment of Maj. Gen. James B. Allison, Chief Signal Officer,” *The Signal Corps Bulletin* no. 84 (May-June, 1935): 2.

[64] Yannis Tsividas, “Edwin Armstrong: Pioneer of the Airwaves,”; Terrett, *The Signal Corps: The Emergency*, 142.

[65] J. B. Allison, “Has the Army Too Much Radio,” *The Signal Corps Bulletin* no. 93 (November - December, 1936): 2.

[66] J. B. Allison, “Some Thoughts on Signal Communications in the Theater of Operations,” *The Signal Corps Bulletin* no. 89 (March-April, 1936): 2-3.

[67] The Infantry Journal, *Infantry in Battle* (Washington, DC: The Infantry Journal, Inc., 1939), Introduction.

[68] Ibid., 179-194.

[69] “Chief Signal Officer of the Army,” *The Signal Corps Bulletin* no. 98 (October-December, 1937): 2.

[70] Raines, *Getting the Message Through*, 232, 238, 242; Terrett, *The Signal Corps: The Emergency*, 41.

[71] Joseph O. Mauborgne, “The Signal Corps,” briefing slides with scripted commentary, Fort Humphreys, DC, U.S. Army War College, September 27, 1938. 1-16, 15 pages of question and answer.

[72] Ibid., 3-4.

[73] Ibid., 4.

[74] Ibid., 5.

[75] Ibid., 5-8.

[76] Ibid., 9-10.

[77] Terrett, *The Signal Corps: The Emergency*, 147.

[78] Mauborgne, “The Signal Corps,” 10-11.

[79] Ibid., 12.

[80] War Department, *Tentative Field Service Regulations Operations, FM 100-5*, (U. S. Government Printing Office, Washington, DC, 1939), 25.

[81] War Department, *Field Service Regulations Operations, FM 100-5*, (U.S. Government Printing Office, Washington, DC, 1939), 36.

[82] Ibid., 37.

[83] Ibid.

[84] "Frequency Modulation Demonstrated," *The Signal Corps Bulletin* no. 105 (July – September 1939): 68-75. The article was reprinted courtesy of *Electronics* magazine.

[85] Terrett, *The Signal Corps: The Emergency*, 142.

[86] Ibid., 144.

[87] Komnenus M. Soukaras, "Signal Communication and the Ultra High Frequencies," *The Signal Corps Bulletin* no. 105 (July – September 1939): 52-57.

[88] Ibid., 52.

[89] Joseph O. Mauborgne, "The Signal Corps," briefing slides with scripted commentary, Fort Humphreys, DC, U.S. Army War College, September 22, 1939. 17 pages with 23 pages of question and answer.

[90] Ibid., 2-3. Q&A

[91] Ibid., 3. Q&A

[92] Karl G. Larew, "From Pigeons to Crystals: The Development of Radio Communication in the U.S. Army Tanks in World War II," *The Historian* 67, no. 4 (Winter 2005): 666.

[93] Terrett, *The Signal Corps: The Emergency*, 145-147.

[94] Raines, *Getting the Message Through*, 240-241.

[95] Ibid., 273-274.

[96] Max L. Marshall, Editor, *The Story of the U.S. Army Signal Corps* (New York City, NY: Franklin Watts, Inc, 1965), 176; Terrett, *The Signal Corps: The Emergency*, 124, 141, 143.

[97] Terrett, *The Signal Corps: The Emergency*, 142.

[98] Ibid., 145.

[99] Ibid.

[100] Ibid., 146, 178.

[101] Larew, "From Pigeons to Crystals: The Development of Radio Communication in the U.S. Army Tanks in World War II," 673.

[102] Terrett, *The Signal Corps: The Emergency*, 145.

[103] Ibid., 45.

[104] Ibid., 145.

[105] David Sarnoff, “Vision of Future Developments,” *The Signal Corps Bulletin* no. 108 (March-April 1940): 11-12. Article taken from Gleason L. Archer’s *Big Business and Radio*.

[106] Ibid., 10-11.

[107] Kotter, *Leading Change*, 72.

[108] Raines, *Getting the Message Through*, 241.

[109] Ibid.

[110] Marshall, Editor, *The Story of the U.S. Army Signal Corps*, 225.

[111] F.W. Von Mellenthin, *Panzer Battles* (New York, NY: Ballantine Books, 1980), 19.

[112] Terrett, *The Signal Corps: The Emergency*, 182-183.

[113] Raines, *Getting the Message Through*, 277.

[114] George Raynor Thompson and Dixie R. Harris, *The Signal Corps: The Outcome* (Washington, DC: Office of the Chief of Military History, 1966, 1985), 491-492. The name of the infantry battalion radio operator was Technician Zens.

[115] Ibid. 491.

[116] Lyons, *David Sarnoff*, 126. Address to the Army War College on January 31, 1927.

[117] Ibid.

[118] S. H. Sherrill, “*Possible Application of Television to Military Signalling*,” (Fort Leavenworth, KS: The Command and General Staff School, May 1, 1932), 1.

[119] Ibid., 12, 16-17.

[120] Ibid., 21.

[121] Edwin C. Meade, “*A Detailed Study of the Possible Military Uses of the Science of Television*,” (Fort Leavenworth, KS: The Command and General Staff School, May 1, 1932) , 1.

[122] Ibid., 32.

[123] Ibid., 2.

[124] David Sarnoff, “Communications Control in War,” briefing slides with scripted commentary, Washington, DC, Army Industrial College, May 4, 1933. Pages 11-13. Also published in *The Signal Corps Bulletin* no. 73, (July-August 1933).

[125] Ibid., 13.

[126] J. G. Harbord, “Radio at War,” *The Signal Corps Bulletin* no. 77 (March - April, 1934): 27; Raines, *Getting the Message Through*, 248.

[127] Ibid., 37.

[128] George L. Van Deusen, “Recent Developments in Signal Communications,” briefing slides with scripted commentary, Fort Humphreys, DC, U.S. Army War College, April 3, 1934. Pages 1-9, 10 pages of question and answers.

[129] Ibid., 8-9.

[130] William S. Rumbough, “The Signal Corps’ Preparation for M-Day,” briefing slides with scripted commentary, Fort Humphreys, DC, U.S. Army War College, October 11, 1937. Pages 1-11, 14 pages of questions and answers. “M” stood for Mobilization.

[131] Ibid., 6 Q&A

[132] Ibid.

[133] George L. Van Deusen, “Television and its Possible Military Applications,” *The Signal Corps Bulletin* no. 105 (July-September 1939): 17-19.

[134] Ibid., 18.

[135] Ibid., 18.

[136] Claire Schwerin, “Army concludes second Network Integration Evaluation,” http://www.army.mil/article/69592/army_concludes_second_Network_Integration_evaluation (accessed November 23, 2011).

[137] Lyons, *David Sarnoff*, 242, 243, 257, 265. Sarnoff’s promotion was on December 7, 1944.

[138] Raines, *Getting the Message Through*, 250; Terrett, *The Signal Corps: The Emergency*, 144.

[139] U.S. Army Human Resources Command, “Training With Industry (TWI) Student Handbook,” https://www.hrc.army.mil/site/protect/branches/officer/leaderdev/civschool/twi_hrc_student_handbook.htm#introduction (accessed December 9, 2011).

[140] Robert M. Gates, *Quadrennial Defense Review* (Washington, DC: U.S. Department of Defense, February 2010), xv.

[141] Michael Gentry, “Next-generation networks and the Defense Department’s command, control, communications, computers, intelligence, surveillance and reconnaissance abilities,” *Army Communicator*, May 3, 2010, http://www.signal.army.mil/ocos/ac/Edition,%20Spring/Spring%2001/NEXTGEN.HTM (accessed December 30, 2011).